Given: Volume Coefficients should be within 0.4-0.7 for horizontal stabilizer and 0.03-0.06 for vertical stabilizer.

Find: Is it possible to have a tail small enough to fit it inside the tube without any folding mechanism? The decision would be based on weight and complexity. The volume coefficients and static margin need to be the priority.

Decision: Increase the length of the fuselage to make smaller stabilizers that can fit in the tube. Consider modifications to fuselage shape to move the position of the wings in the tube. If the weight gain in fuselage is less than the weight of the tail deployment mechanism, then the smaller tail with the longer fuselage would be used.

Design Variables

Variable	Symbol	Constraints
Length of Aircraft	L	36-70 in
Weight of Aircraft	W	Minimized
Fuselage Shape	N/A	N/A
Aspect Ratio for Horizontal Stabilizer	AR_h	>1.5
Aspect Ratio for Vertical Stabilizer	AR_v	>3.0

Measures of Merit

The overall weight of the aircraft and stability are the critical values for this study. While a longer aircraft would allow for smaller stabilizers, the increase in weight might make it infeasible. At the same time, if the volume coefficients are lowered, that would adversely affect the stability of the aircraft which would in-turn affect the aircrafts ability to meet the design objective of having level 1 flying characteristics. The best solution would be a compromise between the two scenarios.

Analysis Methods

The aircraft shape with the initial design did not provide much room for the tail. This can be seen in figure 1. The vertical stabilizer would have to be less than 6 in in height in order to fit, and this was with 2 vertical stabilizers placed as seen in figure 2. This design did put the horizontal stabilizers close to the center of the tube, allowing for the greatest span, without folding, but that still puts the limit to 10 in.

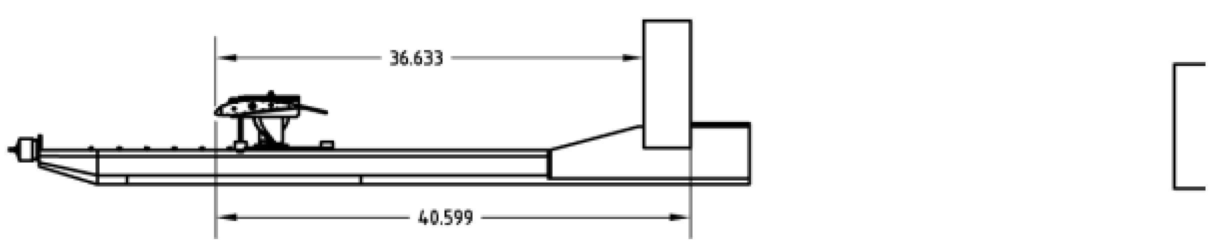


Figure 1: Side View of Aircraft

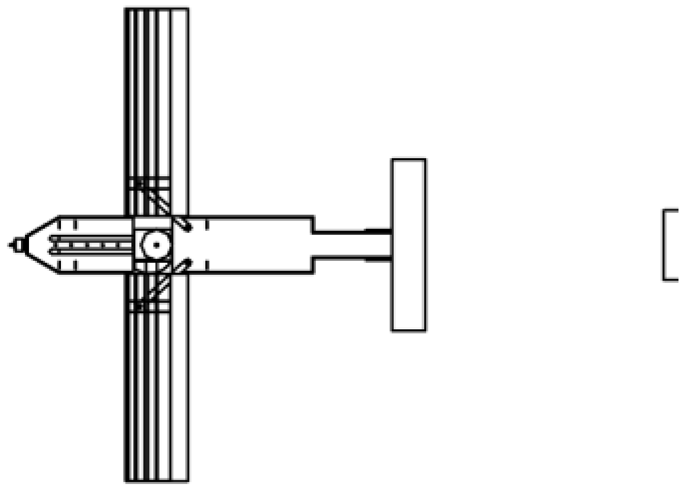


Figure 2: Top View of Aircraft

On further though about the design of the aircraft, in terms of weight and considering room provided for the tail, a modified design (seen in figure 3) was generated. This design uses a Carbon fiber boom at the rear to mount the tail. This design did not affect sizing of the horizontal stabilizers by much, but provided for greater span of the vertical stabilizer, with only one stabilizer, rather than 2.

Figure 3: Side view of Modified Fuselage

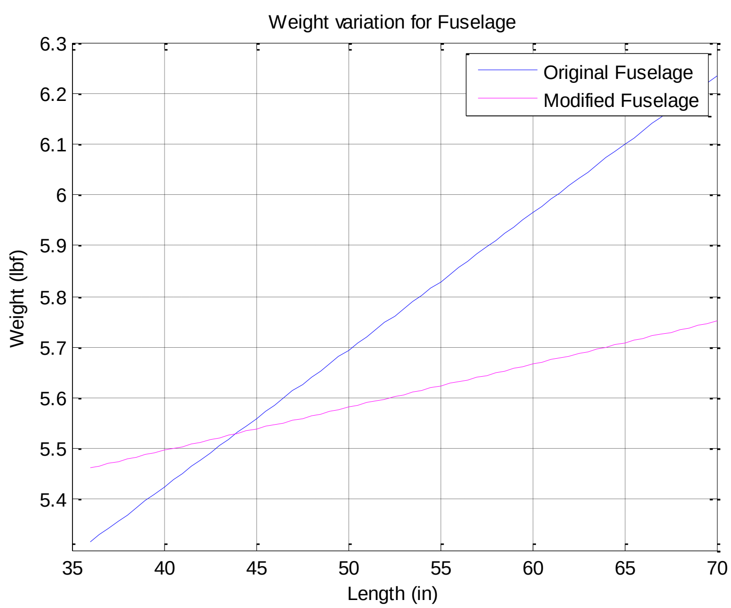


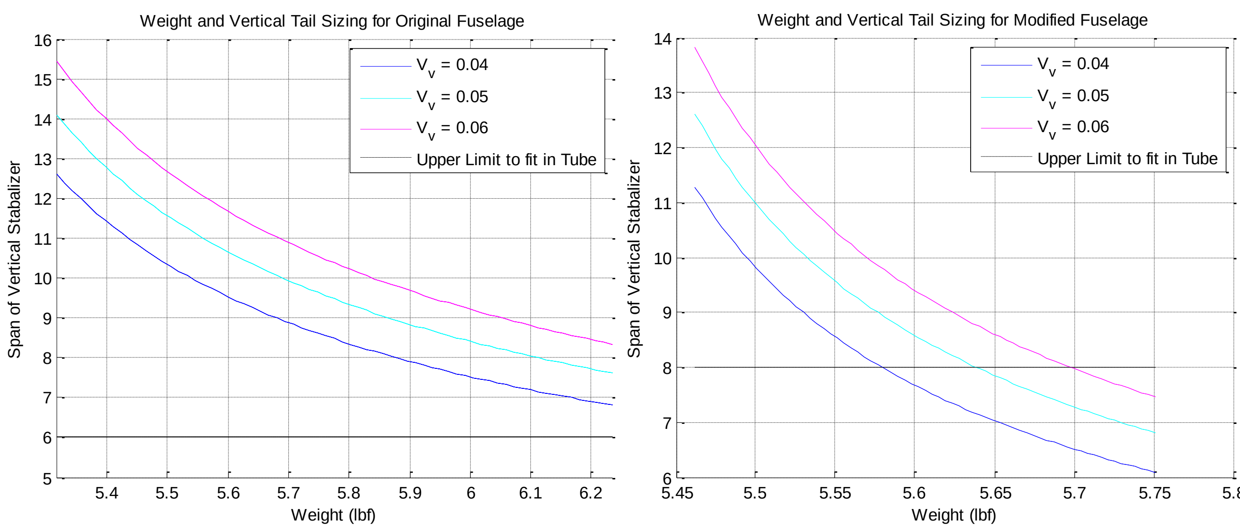
Figure 4: Weight variation with length for different designs.

This modified fuselage allows for less variation in weight with change in length, since only the boom needs to be extended for this design. Figure 4 shows the variation of weight with change in length for the two designs.

With these two designs, the tail was sized for different volume coefficients and changing lengths (which changes the moment arm). The result of this analysis can be found in the results section.

Results

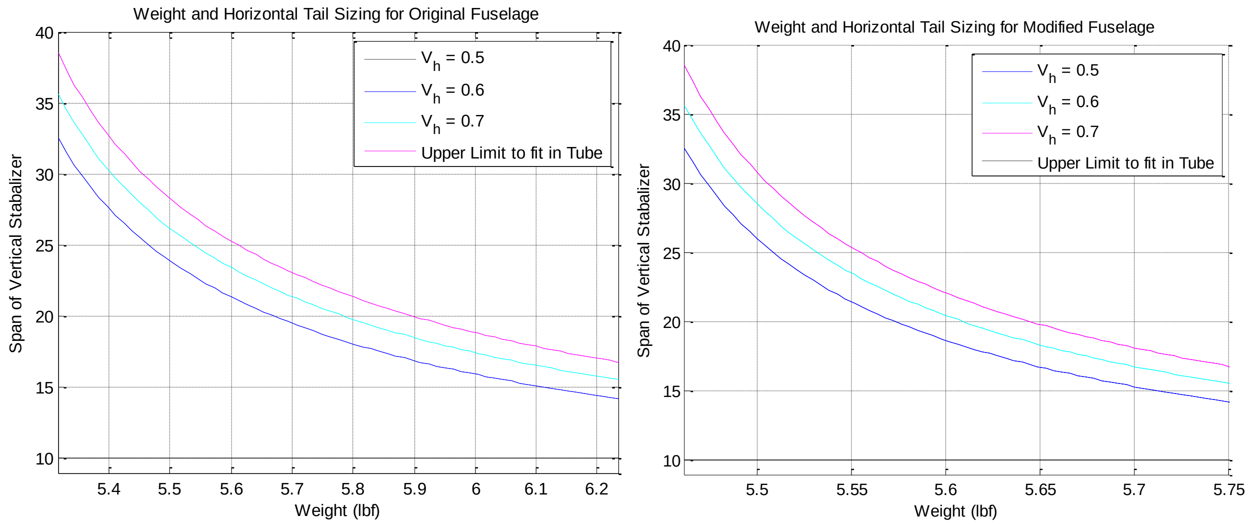
Figure 5 shows the variation of span of the vertical stabilizer with respect to weight for different volume coefficients. It can be seen in figure 5a that it is not feasible to fit the horizontal stabilizer in the original design. In 5b we can see that the vertical stabilizer can be fit in the tube for launch without much gain in weight.



(a) Original Fuselage (b) Modified Fuselage

Figure 5: Vertical Stabilizer Sizing

Similar to the analysis from figure 5, figure 6 shows the variation of horizontal tail span with weight. As it is clear from the two plots in figure 6, neither design can accommodate a horizontal stabilizer that would fit in the tube without any folding mechanism.



(a) Original Fuselage (b) Modified Fuselage

Figure 6: Horizontal Stabilizer Sizing

Impact on Design

The most important impact of this analysis on the design is the new lighter and simpler design of the fuselage. This design allows for greater modularity and a less complex design at the rear of the aircraft. This is especially important since the initial weight estimate for our system was 5.5 lbs and the initial design had already overshot that by about 9%. This new design allows for a lighter aircraft, closer to the estimated weight, and helps us meet the criteria of building the lightest possible aircraft.

The other, more direct impact of this analysis is that we can consider horizontal stabilizers that do not need any deployment mechanism. This further allows for weight savings in the mechanical parts that can be removed from the aircraft. This also adds reliability to the system, because the moving components allow for a greater chance for failure. Unfortunately the Vertical Stabilizer still needs to be folded into the tube since a size that can fit into the fuselage cannot provide enough stability to meet class 1 handling characteristics.